AN OCCUPANT RECOGNITION SYSTEM FOR VEHICLES

Technical Field

5   The invention relates to an occupant recognition system for vehicles comprising at least one pressure sensor arranged beneath the foam of a vehicle seat, at least one temperature sensor and an electronic control and/or evaluation unit to which the sensors are connected.

10   ## Background of the Invention

As a rule, a flexible sensor mat filled with fluid is used with such a passive occupant recognition system to detect the pressure which a weight loading the respective vehicle seat brings about. The sensor mat is arranged beneath the seat foam and consequently at least substantially exposed to the

15   same temperature as the seat foam. Since the pressure measured is dependent on the temperature to a high degree, as a rule a temperature sensor is used to measure the temperature of the system. The temperature sensor is preferably arranged within the electronic control and/or evaluation unit. The physically relevant temperature is, however, the foam temperature.

20   The temperature value measured by the temperature sensor has previously been used for the calculation of the temperature compensation value. On the heating up and cooling down of the vehicle or with all transitional temperature effects, the temperature of the electronic control and/or evaluation unit, however, deviates greatly from the foam temperature. The time constant

25   decisive for the time behavior of temperature is in the range of approximately 30 min. for foam and at approximately 5 min. for the electronic control and/or evaluation unit.

In particular with greater temperature changes, a difference therefore occurs between the temperature measured by the temperature sensor

30   and the temperature actually prevailing in the seat foam. The seat foam heats up more slowly than the temperature sensor or the region in which the temperature sensor is arranged. If now, for example, a decision is made with reference to the pressure measured whether an airbag should be switched on or not, such parameter values as, for example, the empty pressure and the allow threshold

have to be changed in accordance with the temperature measured on the temperature compensation. In the case of greater temperature changes, an incorrect compensation or an incorrect setting of the parameter values in question therefore takes place in the present case based on the temperature

5   measured by the temperature sensor.

Summary of the Invention

It is the underlying object of the invention to provide an improved occupant recognition system of the kind first named in which the

10   previously named problems have been eliminated.

This object is satisfied in accordance with the invention in that means are provided to match the time behavior, in particular the time behavior present on changes in the ambient temperature, of the output signal of the temperature sensor arranged at a distance from the pressure sensor or from the

15   seat foam to the time behavior of the temperature prevailing in the region of the pressure sensor or of the seat foam.

As a result of this design, a temperature signal is now available in the form of the matched output signal of the temperature sensor which is representative for the foam temperature. The correspondingly matched output

20   signal of this temperature sensor can now be used in the electronic control and/or evaluation unit for the compensation of the temperature dependence of the pressure measured via the pressure sensor. Since the correspondingly matched output signal of the temperature sensor is used for the compensation, a reliable compensation is always ensured.

25   The matching means are preferably associated with the electronic control and/or evaluation unit.

In a preferred practical embodiment of the occupant recognition system in accordance with the invention, the matching means include a low-pass filter. In particular a software filter can be used as such a low-pass filter.

30   A Butterworth filter and in particular a Butterworth filter of the first order is preferably provided as the low-pass filter.

The parameters of the filter are expediently selected such that the filtered output signal of the temperature sensor agrees at least substantially with the foam temperature obtained from the trial measurements. On respective changes in the ambient temperature, the filtered output signal of the temperature sensor should therefore behave at least approximately in the same manner as the foam temperature.

As already mentioned, the pressure sensor can in particular include a flexible sensor mat filled with fluid. The pressure sensor can in particular provide a pressure value corresponding to the pressure inside the sensor mat. As the ambient temperature rises, the pressure measured in the flexible mat filled with fluid also rises despite the weight loading the motor vehicle seat remaining the same. This temperature dependence is then compensated using the output signal of the temperature sensor which has been matched to the foam temperature or correspondingly filtered in the manner described.

The pressure sensor is expediently arranged directly beneath the seat foam.

The temperature sensor can in particular include a thermistor.

The temperature sensor can in particular be arranged in the region of the electronic control and/or evaluation unit. It is preferably accommodated in the same housing as this electronic control and/or evaluation unit.

The electronic control and/or evaluation unit is preferably arranged and fastened beneath the vehicle seat.

In a preferred practical embodiment of the occupant recognition system in accordance with the invention, the pressure measured via the pressure sensor is compared by means of the electronic control and/or evaluation unit with at least one parameter value such as an empty pressure value and/or an allow threshold and a decision is made in dependence on the result of the comparison whether an airbag is switched on or not, with the relevant parameter value being changed accordingly as part of the compensation of the temperature dependence.

In accordance with the invention, a software filter is therefore preferably used to obtain an estimated value for the foam temperature in particular on the basis of the measured temperature of the electronic control and/or evaluation unit after a corresponding filtration.

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Brief Description of the Drawings

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a time diagram from which the different influence of

10   a changing ambient temperature on the foam temperature and on the temperature of the electronic control and/or evaluation unit results;

Figure 2 is a circuit diagram of a Butterworth low-pass filter of the first order for the filtering of the output signal of the temperature sensor;

Figure 3 is a time diagram from which the respective time curve

15   of the temperature measured via the temperature sensor, of the measured foam temperature and the output signal of the temperature sensor filtered by means of the Butterworth low-pass filter results; and

Figure 4 is a further time diagram in which the output signal of the filter and the output signal of the temperature sensor are again compared

20   with one another.

Description of the Preferred Embodiment

The different influence of a changing ambient temperature on the foam temperature and on the temperature of the electronic control and/or

25   evaluation unit measured by the temperature sensor results from the time diagram in accordance with Figure 1. The curve T_{ECU} represents the development of the temperature prevailing in the control and/or evaluation unit and the curve T_{Foam} represents the development of the foam temperature.

As already mentioned, the pressure sensor can in particular be a

30   flexible sensor mat filled with fluid. The pressure in this sensor mat is temperature dependent. The pressure measured in the sensor mat thus also increases as the ambient temperature increases despite the weight on the vehicle

seat remaining the same. A decision is made by means of the control and/or evaluation unit with reference to the measured pressure whether, for example, an airbag is switched on or not. Consequently, a temperature compensation is required, i.e. the parameter values such as the empty pressure and the allow

5   threshold are changed in accordance with the temperature measured.

The temperature sensor or thermistor provided for this purpose in the occupant recognition system is disposed in the electronic control and/or evaluation unit of the system which can in particular be arranged and fastened beneath the vehicle seat. At extreme temperature changes, the temperature T_{ECU}

10   measured by the temperature sensor and the actually prevailing temperature in the seat foam T_{Foam} differ form one another. The seat foam thus heats up more slowly than the temperature sensor or thermistor. However, it is the temperature T_{Foam} of the seat foam which is relevant for the measured pressure so that in the case of extreme temperature changes in the vehicle, for example the empty

15   pressure and the allow threshold would be incorrectly compensated on the basis of the temperature measured by the temperature sensor.

Two different heating procedures must now be considered, namely that of the temperature sensor or thermistor and that of the seat foam. It must be considered here that the seat foam heats up more slowly due to its heat

20   insulating properties than the pressure sensor or the region in which it is arranged.

In a preferred embodiment of the occupant recognition system in accordance with the invention, an approximation to the foam temperature T_{Foam} now takes place in that the output signal of the temperature sensor or thermistor

25   is filtered by means of a Butterworth low-pass filter of the first order. In Figure 2, such a filter is shown which is provided with the reference numeral "10" here.

On the filtering of the output signal of the temperature sensor by means of such a Butterworth low-pass filter of the first order, a temperature curve is obtained which agrees very well with the temperature prevailing in the

30   foam. A temperature compensation based on such a filtered temperature signal is correspondingly more precise.

A corresponding low-pass filter at a very low cut-off frequency has the effect that fast changes in the thermistor signal, for example due to a fast heating up of the inner space of the motor vehicle – are delayed and a temperature development is accordingly simulated which corresponds to the heating up procedure of the seat foam. At a constant temperature or at a small temperature gradient, the filter 10 has no effect.

Before the preferred numerical realization of the filter is looked at, the likewise feasible analytical approach should also be mentioned beforehand:

The solution of the differential equation for the heat transfer provides

$$1) \quad T_{ECU} = T_\infty + (T_{ECU,\,t=0} - T_\infty) \cdot e^{-\frac{t}{\tau_{ECU}}}$$

$$2) \quad T_{Foam} = T_\infty + (T_{Foam,\,t=0} - T_\infty) \cdot e^{-\frac{t}{\tau_{Foam}}} ,$$

where the two time constants τ_{ECU} and τ_{Foam} for the electronic control and/or evaluation unit (ECU) and the foam (Foam) differ from one another. These time constants can, for example have the following values:

$$\tau_{ECU} \approx 10 \text{ min.}$$
$$\tau_{Foam} \approx 30 \text{ min.}$$

The ideal solution would be as follows:

The determination of the ambient temperature T_∞ from the temperature T_{ECU} of the electronic control and/or evaluation unit and its temporal derivation $\dot{T}_{ECU}$ becomes

$$3) \quad T_\infty = T_{ECU} + \tau_{ECU} \cdot \dot{T}_{ECU},$$

from which the following results:

$$4) \quad T_{Foam} = (T_{ECU} + \tau_{ECU} \cdot \dot{T}_{ECU}) + \Delta T_{t=0} \cdot e^{-\frac{t}{\tau_{ECU}}},$$

5   where $\Delta T_{t=0} = T_{ECU, t=0} - T_{\infty}$.

However, this only applies to a stationary process (T_{∞} = const.).

In the preferred numerical realization of the filter, the current measured value (n) of the temperature sensor and its preceding value (n-1) are required for the calculation of the foam temperature.

10   The input value "Ein" of the Butterworth low-pass filter of the first order shown in Figure 2 is the temperature T_{ECU} measured by the temperature sensor. The output value "Aus" corresponds to the foam temperature T_{Foam}.

The following relationship applies to the foam temperature

15   T_{Foam}:

$$5) \quad T_{Foam} = C \cdot z(n) + D \cdot T_{ECU}(n).$$

The intermediate value $z(n)$ is calculated from its predecessor

20     $z(n-1)$ and from the preceding measured value $T_{ECU}(n-1)$ of the temperature sensor or thermistor:

$$6) \quad z(n) = A \cdot z(n-1) + B \cdot T_{ECU}(n-1),$$

25   where the start value results from the following relationship:

$$7) \quad z(0) = T_{ECU}(0) \cdot (1 - D)/C$$

The parameters A, B, C and D of the Butterworth low-pass filter

30   10 are preferably selected such that the filtered temperature signal agrees with the foam temperature gained from trial measurements. They are determined by

the cut-off frequency of the filter 10 and can be calculated with corresponding software.

The time diagram in accordance with Figure 3 gives the respective time development of the temperature T_{ECU} measured via the temperature sensor, of the measured foam temperature T_{Foam} and of the output signal T_{10} of the temperature sensor filtered by means of the Butterworth low-pass-filter 10. Accordingly, the filtered output signal T_{10} largely agrees with the actual foam temperature T_{Foam} such that a precise temperature compensation is possible based on it.

Figure 4 shows a further time diagram in which the output signal T_{10} of the filter 10 and the output signal T_{ECU} of the temperature sensor are again compared with one another at a different scale.